

Addendum to Air Quality: Decision Support Tools, Partner Plans, Working Groups, Committees

Section 2.0 Major Federal Agency Air Quality Programs

2.6 Tennessee Valley Authority

The Tennessee Valley Authority (TVA) strategic plan for 2004, *Tennessee Valley Authority Strategic Plan: A Framework for a Competitive Future*, includes environmental stewardship as a mission. However, this mission contains no specific references to air quality. The only references to air quality within the strategic plan occur in relation to power generation and the need for emissions control due to air quality regulations imposed by the Clean Air Act. Because the TVA is a hybrid between a government agency and industry, the strategic plan differs from those of Federal agencies by focusing mainly on production and debt reduction rather than placing an emphasis on partnerships and technology development. However, an air quality research program identified within the TVA may benefit from incorporation of NASA data.

2.6.1 Background

Congress created the Tennessee Valley Authority in 1933 to enhance the quality of life in the Tennessee Valley region. This objective has been accomplished by providing flood control and maintaining navigation on the Tennessee River, the fifth largest river system in the country, and by generating and transmitting electricity in the seven-state Valley region. TVA meets the power needs of 8.3 million people in an 80,000-square-mile area via 158 power distributors and directly serves large-area industries as well. TVA's electric power system includes 59 coal-fired units at 11 sites, 3 nuclear plants, 29 hydropower plants, 6 combustion-turbine plants, 3 wind turbines, and 15 solar installations. Thus, a mix of fossil, nuclear, hydroelectric, and renewable sources aids in the reliability of power generation. These systems account for over \$7 billion in annual energy sales that pay for all TVA activities, including flood control, land management, and environmental research.

Through the Clean Air Act, Congress mandated the protection and enhancement of the Nation's air quality resources. National Ambient Air Quality Standards for the following pollutants have been established to protect the public health and welfare:

- Sulfur dioxide (SO₂)
- Ozone (O₃)
- Nitrogen dioxide (NO₂)
- Particulate matter <10 µm in diameter (PM₁₀) and <2.5 µm (PM_{2.5}) in diameter
- Carbon monoxide (CO)
- Lead (Pb)

Other regulatory programs affecting emissions include the Acid Rain Control Program and the Regional Haze Rule.

Furthermore, the Air Quality Research Subcommittee of the Committee on the Environment and Natural Resources has identified in its Strategic Plan five of the most pressing air quality issues today: 1) particulate matter and visibility, 2) ozone and associated air pollutants, 3) acidic deposition, 4) hazardous air pollutants, and 5) indoor air quality. Clearly, these issues are interdependent and many of the associated phenomena are interrelated. For example, the same complex chemistry that produces ozone also results in the formation of fine particles and the acids responsible for acidic deposition.

Air pollutant emissions from TVA plants have been documented to contribute to a degradation of regional air quality. Nitrate, sulfate, and ozone are secondary pollutants derived from the burning of fossil fuels (coal) at these plants. Once these secondary pollutants are created from the primary emissions, they become airborne, affecting human populations, regional visibility, soil/vegetation health, and water quality. Haze is created as emitted sulfur travels east on prevailing air currents and admixes with the humid air. Haze affects the appearance of mountain views at both high and low elevations. Additionally, area ozone produced by the reaction of nitrogen oxides and volatile organic compounds in the presence of sunlight is one of the most widespread pollutants that strongly affects not only vegetation but also public health.

TVA has moved to comply with Environmental Protection Agency (EPA) concerns for the environment. TVA has reduced sulfur dioxide emissions by 76 percent since 1977. In addition, TVA has reduced ozone-season emissions of nitrogen oxide by 50 percent in the past 8 years. This reduction has occurred despite the fact that since 1990, the population in the TVA service area has grown by more than 15 percent, gross regional product has grown by nearly 50 percent, and demand for electricity has grown by more than 10 percent. To meet these needs, TVA expects to increase its capacity more than 10 percent through 2005. However, most of the increased capacity will be generated using non-coal burning turbines that operate on natural gas or oil.

2.6.2 Synopsis of Air Quality Efforts

The primary objective of TVA's air quality program is focused on issues that are important to the Tennessee Valley region. Ongoing monitoring and research programs are intended to improve the understanding of the underlying factors that control the distribution of pollutants in the atmosphere. These programs include laboratory studies, long-term monitoring, intensive field studies, and model development and application. Studies are being conducted on ground-level ozone, acid rain, particulate matter, and other air toxics. These activities are conducted in collaboration with Federal agencies, universities, and stakeholder groups. Monitoring and research results are transferred to the policy/regulatory community, where they are employed in the development of effective control strategies.

TVA has traditionally looked at larger scale air quality assessments but recently has begun to refine the scale of its monitoring and modeling to include smaller spatial scale events. The following is a listing of air quality concerns for TVA:

- Regional haze and visibility
- Ozone
- Fine particulates

- Chemical and physical composition of pollutants
- Meteorological conditions

Of particular concern are fine particulates, visibility, and ozone – which are interlinked in their net effects on air quality. Airborne fine particles, especially PM_{2.5}, have been linked to adverse health effects and regional haze. Regional visibility is estimated to have declined by as much as 60 percent over the past 50 years in the eastern United States. Much regional haze is due to fine sulfate particles. Some sulfates can originate from natural sources, but most regional haze is caused by fine, anthropogenic sulfate particles. Ozone is also a cause of haze, which, again, limits visibility and can induce health problems in local populations. Exposure to high levels of ozone can harm lung tissue, impair lung function, and sensitize the respiratory system. Recent evidence suggests that elevated ozone exposure not only affects those with existing health problems, such as asthma or heart disease, but also may be detrimental to healthy people.

Presently, TVA and its program partners are pursuing monitoring and modeling programs for PM_{2.5}, visibility, and ozone. Most emphasis is placed upon sulfate detection and visibility issues. TVA works with state and local air quality agencies to monitor air quality via *in-situ* monitoring sites. The data gathered is sent to the EPA and incorporated into a standing database. This database is used in various ways by the different partner agencies to provide both an ongoing assessment of conditions as well as a baseline for new companies locating within the TVA area. TVA currently operates 11 air-quality compliance-monitoring stations. Nine stations in Alabama and Tennessee measure hourly levels of sulfur dioxide near TVA power plants to demonstrate continuing compliance with clean air standards. Two ozone compliance-monitoring stations are located at the TVA Paradise and Shawnee fossil power plants in Kentucky.

According to TVA representatives, research is being pursued in modeling and field activities. For example, in the Great Smoky National Park area, monitoring is ongoing to determine particulate character and size distribution that causes reduced visibility in scenic park areas. The Look Rock monitoring site includes a Web cam for an assessment of the visibility on a given day. Modeling involves exercising the Community Multiscale Air Quality (CMAQ) and CALPUFF models for relevant data inputs and geographical areas.

2.6.3 Projects and Observations

In 1992, the Southern Appalachian Mountain Initiative (SAMI) was formed as a public-private regional partnership to address air quality concerns in the region. The partnership's goal was to “identify and recommend reasonable measures to remedy existing and prevent future adverse effects from human-induced air pollution on the air quality related values of the Southern Appalachians.” SAMI consisted of representatives from the eight states in the region, the EPA, the National Park Service, the U.S. Forest Service, TVA, industries, environmental organizations, and interested citizens. The final report evaluated the need for further emissions reductions and identified the most cost-effective approach to minimizing negative effects from air pollution.

A current spin-off program from SAMI was the Visibility Improvement State and Tribal Association of the Southeast (VISTAS), which was formed as a Regional Planning Organization to help develop and implement EPA and state air quality plans. VISTAS is a collaborative effort established to coordinate activities associated with the management of regional haze and other air quality issues in

the southeastern United States. TVA is actively participating in VISTAS meetings and data collection activities. VISTAS seeks to

- create a visibility database,
- select air quality modeling episodes,
- develop an emissions database, and
- perform meteorological and air quality modeling.

TVA is conducting research in cooperation with other organizations to address the primary technical issues faced by VISTAS.

The Aerosol Research and Inhalation Epidemiology Study (ARIES) was initiated in 1997 by the Electric Power Research Institute in cooperation with the EPA, the U.S. Department of Energy, and several electric utilities, including TVA. The study was created to provide science-based knowledge that would help lead to improved air quality and more effective protection of public health. ARIES data collection focused on PM_{2.5} health effects by providing data for the full range of relevant air pollutants—gases and particulate matter. TVA has been monitoring fine particulates (i.e., PM_{2.5}) since 1978, but a comprehensive network did not begin operation until 1999. While measures of larger pollutant particle size indicate significant improvements over the last two decades, PM_{2.5} measurements had not been collected long enough to establish meaningful trends. The pertinent data collection effort has been completed; however, work continues on data reduction and analysis.

TVA also actively participates in the Southern Oxidants Study. The ground-based air quality monitoring stations used in this study can be divided into three groups based on their level of sophistication. More than 20 Level-1 monitoring stations provide broad coverage across Nashville/middle Tennessee and portions of neighboring states. State and local regulatory organizations, industries, and others who voluntarily participate in the study operate these ozone and fine particle monitoring stations. Two Level-2 chemistry-monitoring stations provide detailed atmospheric chemistry information on ozone, sulfur dioxide, carbon monoxide, volatile organic compounds, and nitrogen oxides. These Level-2 stations are polled each day to provide a detailed picture of regional and local atmospheric chemistry. A Level-3 research chemistry “super station” is operated in Nashville at Cornelia Fort Airpark. This station, located about 8 km northeast of the Nashville urban core, provides a detailed picture of atmospheric chemistry by using advanced developmental measurement techniques to study concentrations of ozone, fine particles, and associated precursor compounds.

Future work includes continued modeling, monitoring – especially PM_{2.5} monitoring – and pollution chemistry research. An example of a key chemistry research area relates to the aging of airborne sulfur compounds to ammonium sulfate. The cycle of decay of long-lived ammonium sulfate, although not well understood, is a large contributor to haze and particulate pollution. Ground-level station monitoring of ammonium sulfate is not considered sufficient to understand the life cycle and dispersion of this compound. Vertical profiles are needed to better confront the problem.

A synoptic assessment, or mapping, of atmospheric visibility (haze levels) over TVA targeted areas would be helpful to TVA researchers. Moreover, the ability to track where a given air mass has been (hindcast), given complex terrain, would be of help to TVA scientists.

NASA carries out research in several areas relative to the distribution of aerosols in the atmosphere and the processes that control aerosol composition. Significant elements of NASA programs include 1) laboratory and model studies of processes by which aerosol particles form in the atmosphere and the relationship between chemical and physical properties of particles and the conditions under which they form, 2) *in situ* measurements of particle properties and those of precursor species, typically made through airborne platforms that fly in the upper troposphere and lower stratosphere, and 3) remotely sensed measurements of aerosols, providing some information on properties such as concentration, size distribution, optical depth.

For particulate matter studies, column measurements of aerosol presence over land are of interest for haze mapping. The Stratospheric Aerosol and Gas Experiment (SAGE III) and the Total Ozone Mapping Spectrometer (TOMS) can contribute to these measurements. Further, the Moderate Resolution Imaging Spectroradiometer (MODIS) could also supply additional related measurements.

NASA carries out research in several areas relating to the distribution of ozone and other trace gases in the global troposphere and to processes that control tropospheric ozone concentrations. NASA's tropospheric chemistry research helps provide a scientific and geophysical perspective for the more focused interest in tropospheric chemistry and air pollution carried out by other agencies.

Particular elements of related NASA programs include 1) laboratory studies of the chemical processes important in the chemistry of the global troposphere, including both gas phase and heterogeneous chemical processes, 2) *in situ* and remotely sensed measurements of concentrations of ozone and related trace gases in the troposphere and stratosphere typically made through airborne platforms, and development of new instrument technology suitable for use on airborne platforms, 3) development of large regional-scale and global models simulating the trace constituent composition of the global troposphere and the role that chemical, microphysical, and meteorological processes play in controlling ozone concentrations, and 4) remotely sensed measurements of concentrations of relevant gases in the atmosphere.

For air contaminant studies, synoptic measurements of tropospheric ozone (column-integrated) made by SAGE III and TOMS could be of greatest interest. Measurements of the vertical distribution of carbon monoxide in the troposphere (and total column methane) can be made available from the Measurements Of Pollution In The Troposphere (MOPITT) instrument onboard the Terra spacecraft.

2.6.4 Conclusions

TVA has ongoing air quality issues deriving from power generation in the Tennessee Valley region. Although TVA has and is endeavoring to improve air quality, there is pressure to further increase power generation due to a steady growth in area power demand. TVA is partnering with other agencies at various levels, as well as with other interested groups, to perform program research and to provide air quality monitoring data, with the goal of further attenuating regional pollutant-related air quality problems.

NASA can make a contribution to the TVA air quality efforts using both in-house technical expertise (e.g., prominent technical groups exist at Goddard and Marshall Space Flight Centers) and NASA remote sensing data streams. In particular, MODIS, TOMS, SAGE III, and MOPITT are sensors whose data could be ingested into TVA's air quality program to aid air quality management decisions. Partnering with TVA is recommended.

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